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CORRELATION BETWEEN AROMA AND VOLATILE COMPOSITION OF McINTOSH APPLES

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ABSTRACT

The relationship between aroma and volatile composition of McIntosh apples was investigated. Significant correlations were found between aroma qualities determined organoleptically by a trained panel and by GLC. Unripe apples contained low levels of all volatiles and exhibited grassy and green aroma notes. C-6 aldehydes correlated with overall aroma intensity, ripeness, and fruity and aromatic notes. Esters correlated with a cheesy aroma note. Overripeness correlated with esters and total peaks in unstored but not in stored apples. The GLC peak groups which previously were found to correlate with physical and chemical properties related to maturity in unstored McIntosh apples also correlated with aroma.

INTRODUCTION

THE RELATIONSHIP between aroma, determined by sensory evaluation, and the volatile composition of McIntosh apples was investigated. In a previous study (Sapers et al., 1977) the volatile content of McIntosh apples was correlated with other chemical and physical measurements (such as acidity, soluble solids, Magness-Taylor firmness, and the nondestructive measurement of sonic resonance frequency) to help establish a potential tool for sorting apples. Finney et al. (1978) correlated nondestructive sonic resonance measurements with the texture of apples. Since the flavor of apples is a very important determinant of quality, and aroma is an integral component of flavor, a complete description of apple quality should include the aroma. Therefore, correlating aroma with volatile composition provides an important quality measurement for McIntosh apples, especially since volatiles are also correlated with other physical and chemical measurements.

MATERIALS & METHODS

Materials

McIntosh apples were harvested in an orchard in south central Pennsylvania on three dates: 2 wk before the harvest date anticipated by the grower, at normal harvest time, and 2 wk after this time. Each harvest was separated into two groups: apples to be examined immediately and apples to be placed in storage. From the first group, 12 apples were taken and the juice was extracted immediately; 12 additional apples from this group were ripened for 5 days at 21°C and then extracted. The second group was stored for 5 months at 1°C and 85% relative humidity and then examined the same way as the first group. This procedure was followed to provide apples with as varied an aroma as possible.

Experimental designs

Juice extraction and storage. Since it is difficult to run simultaneous GLC analyses and sensory evaluations, a method for juice extraction and storage had to be developed which would allow us to carry out these evaluations at different times with minimal changes in the juice. After experimenting with different preparative conditions, such as the use of a nitrogen atmosphere, dry ice, open and closed collecting containers, quick and slow freezing and thawing, we established that fresh apple juice underwent the least change when the following procedure was used. The juice was extracted with an Acme Supreme Juicerator and collected in a 250 ml Erlenmeyer flask immersed in an ice bath; immediately after the extraction, aliquots were poured into two bottles, one for GLC analysis and one for sensory evaluation. Both bottles were quickly frozen in a freezer set at −18°C. For both sensory and GLC analyses, the bottles were placed in a crystallizing dish containing water at room temperature and were thawed in a refrigerator. With this method, the only noticeable change in the apple juice was a slight increase in a GLC peak tentatively identified as hexanal (Sapers et al., 1977), which was unavoidable since it occurred during and immediately after extraction of an apple. (We observed differences in this peak for juice aliquots taken at different times during the extraction of an apple.)

Measurement of volatile levels

A headspace vapor GLC method previously used in our laboratory (Sapers et al., 1977) was modified by decreasing the juice sample to one-third to permit both GLC analysis and sensory evaluations on the same apple. When GLC headspace vapor analyses were completed on apple juice from all the unstored apples, the juice samples were classified into 13 groups based on the GLC peak profiles. The purpose of this classification was to establish whether apples having the same pattern of GLC peaks were similar in aroma (or lack of aroma), and how changes in individual peaks affected aroma. As can be seen from Table 1 the first group A was comprised of apple juice samples in which all GLC peaks were very small or did not show up at all. As soon as a peak in a chromatogram increased or decreased substantially, that chromatogram was put into a separate group (all other peaks being the same). This can be illustrated by group B which was like group A, except for peak 12 which became moderate in size. Group D differed from C by having larger peak 18, but smaller peaks 12, 21, 22a, and 30. All subsequent chromatograms were grouped in the same manner according to an increase or decrease in magnitude of one or more particular peaks. The last group was comprised of chromatograms whose major peaks were exceptionally large. Within a group, differences between peak areas were very small. Juice samples corresponding to characteristic profiles were submitted to the aroma panel for evaluation. Four samples representing different groups were presented at each session. The same procedure was followed with apples stored for 5 months.

Sensory evaluation

The sensory evaluation had three objectives:

1. To estimate the magnitude of aroma as described by overall intensity.
2. To establish degrees of ripeness: unripe, ripe, overripe.
3. To define descriptive qualities, "notes" of aroma such as: green, grassy, wild rose, aromatic, fruity, musty rotten, cidery fermented, and estery.

For sensory evaluation we used the method of Quantitative Descriptive Analysis (Stone et al., 1974). All apple juice samples were coded and randomized. Teflon wash bottles (150 ml) containing 30 ml of juice were used for smelling. Sample bottles were wrapped in white paper to obscure differences in the juice appearance. Samples were presented to the panel at room temperature. All sessions were conducted in a room under positive pressure, with fresh air being brought in from outside through carbon filters and maintained at 23°C. All sessions were conducted at 1:30 p.m. once or twice a week. From a group of 30 people experienced in sensory testing, whom we screened for their ability to detect and identify odors, nine were selected (Land, 1975). The first task of the panel was to develop a vocabulary to describe aroma present in the McIntosh apples at various stages of maturity, from green to overripe. This was done first with fresh fruit, then with the juice from McIntosh apples representing known stages of development. A discussion period followed each session at which the descriptive vocabulary was developed. (When possible, illustrative material was made available, for example, ethyl-butyrate, an important constituent of McIntosh

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Table 1—Peak area ratios[a] of unstored McIntosh apples

Peak no.	Mean peak area ratio												
	Group												
	A	B	C	D	E	F	G	H	I	J	K	L	M
10	0.001	0.001	–	–	0.010	0.001	0.008	0.001	0.016	0.013	0.014	0.009	0.039
12	0.011	0.497	0.233	0.014	0.012	0.055	0.078	0.052	0.179	0.132	0.253	0.646	1.021
13	–	–	–	–	–	0.072	0.092	0.050	0.264	0.239	0.420	0.490	0.775
15	0.001	–	0.003	0.010	0.009	0.019	0.023	0.023	0.048	0.051	0.117	0.070	0.124
16	–	–	–	–	–	0.003	0.004	0.003	0.006	0.014	0.016	0.005	0.008
18	–	0.001	0.037	0.130	0.201	0.468	0.897	0.326	2.154	1.796	2.444	1.597	3.164
19	–	–	–	0.003	0.005	0.068	0.086	0.043	0.277	0.243	0.298	0.254	0.423
21	0.028	0.022	0.122	0.018	0.034	0.286	0.196	0.281	0.253	0.194	0.277	0.250	0.211
22a	0.003	0.015	0.086	0.036	0.080	0.364	0.243	0.243	0.195	0.278	0.341	0.545	0.209
25	0.009	0.018	0.019	0.027	0.084	0.085	0.074	0.065	0.071	0.085	0.103	0.180	0.075
26	–	–	–	–	–	0.034	0.019	0.033	0.208[b]	0.027	0.036	0.035	0.194[b]
27	0.005	0.003	0.008	0.004	0.041	0.089	0.100	0.091		0.148	0.165	0.142	
30	0.012	0.014	0.115	0.020	0.095	0.249	0.294	0.242	0.190	0.301	0.353	0.565	0.235
No. of apples anal.	7	8	3	3	3	3	6	2	5	4	3	4	3

[a] Ratio of peak area/internal standard peak area
[b] For groups I and M peaks 26 and 27 were not resolved.

apples.) Panelists indicated the magnitude of aroma by marking an unstructured 10 cm line. GLC and sensory data were obtained for 54 unstored and 62 stored apples. The unstored apples were classified into 13 groups based on similar GLC peak profiles, and stored apples were classified into 11 groups. Correlations between headspace vapor volatiles and sensory data were computed for group averages. A two-sided significance test was used, and correlation coefficients significant at the 0.01 level are reported (Snedecor and Cochran, 1967).

RESULTS & DISCUSSION

THE FIRST OBJECTIVE of the sensory evaluation was the measurement of the magnitude of aroma as described by overall intensity. We found that it correlated with the sum of two GLC peaks tentatively identified as the C-6 aldehydes, hexanal and 2-hexenal, for both stored and unstored apples (Table 2). Our second objective was to correlate the sensory perception of the degree of ripeness with headspace volatiles. Unripe aroma quality correlated negatively with total peak area, while ripe aroma correlated with C-6 aldehydes for both stored and unstored apples and with total peak area only for stored apples (Table 2). In unstored apples overripeness correlated with the sum of volatile esters listed in Table 3 and total peak area (Table 2). In stored apples, correlations between overripeness and volatiles were not significant. During aroma panel sessions, panelists had difficulty in perceiving the overripe quality of aroma with stored apples and tended to assign high scores for ripeness instead. However, they still readily identified the "cheesy" note, which was closely related to overripeness in unstored apples. Paillard (1975) stated that it is the proportion of volatile components in apples which forms the character of aroma of each variety and not individual volatiles. This could partly explain why the panel had difficulty in perceiving the overripe aroma in stored apples, since on storage the volatile composition of apples undergoes substantial change. For example, ethanol (peak 12) and ethyl propionate (peak 13) are greatly increased, and, although ethanol (peak 12) showed no correlation with aroma, it greatly changed the proportions between volatile components and especially affected the total peak area. The perception of overripeness in unstored apples correlated highly with total peaks.

The third category of sensory evaluation, i.e., descriptive quality or "note," showed very high and distinct correlations with volatile components. Esters correlated highly with the "cheesy" aroma (Table 2) for both unstored and stored apples, while aldehydes correlated highly with aromatic and fruity notes, especially hexanal (peak 21) (Fig. 1). Flath et al. (1967) cited hexanal and 2-hexenal as two of the components directly associated with the characteristic apple-like aroma in Delicious apple essence. As was expected, unripe apples contained low levels of all volatiles, and, as the volatile components increased, the sensory perception of aroma notes such as grassy and green decreased, resulting in negative correlations between GLC and sensory data (Table 2).

Table 2—Correlation between volatile levels and aroma in McIntosh apples

GLC volatiles[a]	Aroma	Correlation coefficient	
		Unstored	Stored
C-6 aldehydes	Overall intensity	0.63	0.78
	Ripe	0.68	0.80
	Aromatic	0.81	0.82
	Fruity	0.63	0.85
Esters	Overripe	0.85	N.S.[b]
	Cheesy-butyric	0.90	0.74
Total peak area	Unripe	–0.59	–0.87
	Ripe	N.S.[b]	0.75
	Overripe	0.84	N.S.[b]
	Green	–0.69	–0.69
	Grassy	–0.63	–0.75

[a] Headspace vapor components
[b] N.S. = Not significant.

Table 3—Headspace vapor esters

Peak no.	Tentative identity
13	Ethyl propionate, ethyl 2-methylpropionate
15	Methyl butyrate
16	Methyl 2-methylbutyrate
18	Ethyl butyrate
19	Ethyl 2-methylbutyrate
22a	Ethyl pentanoate

Table 4—Correlation between individual GLC peaks and sensory data

Peak no.	Tentative identity	Aroma	Correlation coefficient Unstored	Stored
13	Ethyl propionate	Overripe	0.85	N.S.[a]
		Cheesy	0.84	0.62
18	Ethyl butyrate	Overripe	0.85	N.S.[a]
		Cheesy	0.93	0.71
19	Ethyl 2-methylbutyrate	Overripe	0.85	N.S.[a]
		Cheesy	0.90	0.72
21	Hexanal	Ripe	0.66	0.83
		Fruity	0.61	0.90

[a] N.S. = Not significant.

Table 5—Correlation between volatile levels and indices of maturity and ripeness in McIntosh apples (1974—75 study)[a]

GLC volatiles	Correlation coefficient Stiffness coefficient	Acidity	Magness-Taylor
Aldehydes	−0.72	−0.73	−0.67
Esters	−0.69	−0.68	−0.63
Total peaks	−0.74	−0.74	−0.69

[a] Sapers et al. (1977)

Correlations between sensory data and individual peaks are summarized in Table 4. Individual peaks, whether they be aldehydes or esters, showed the same general correlations as the groups. Correlations between alcohols and aroma notes were not significant.

In our previous investigations with McIntosh apples, we established correlations between individual volatile components and physical and chemical characteristics such as sonic resonance frequency (stiffness coefficient), acidity, and Magness-Taylor firmness (Sapers et al., 1977). Correlations between these parameters for McIntosh apples (which were not stored) in the 1974—75 study were recalculated to conform with the current peak classification system (Table 5). For apples stored 4 months, these correlations were not significant. Correlations between sonic resonance frequency and volatile composition are of special interest, since the former measurement is nondestructive and could be used in sorting apples. The results obtained in our current investigation show that important aroma qualities can indeed be related to specific GLC components or to groups of components. For unstored McIntosh apples these same groups of volatile components can be correlated to other chemical and physical measurements such as acidity, Magness-Taylor firmness, and especially sonic resonance frequency.

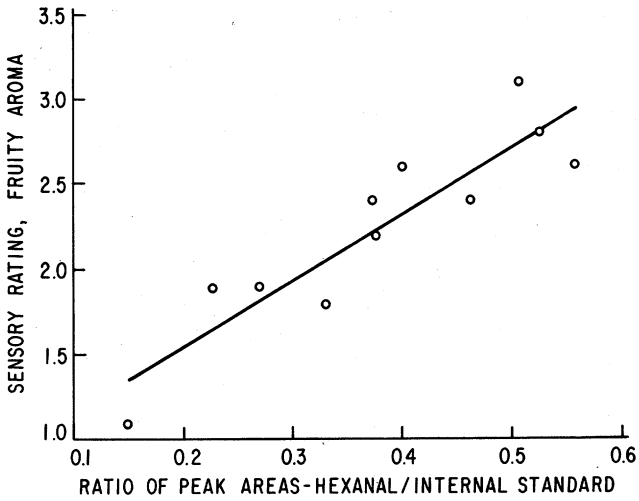

Fig. 1—Correlation between fruity aroma and hexanal (peak 21).

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